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IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF	:
ERIC J STRANG	: EXAMINER: SIEK, VUTHE
SERIAL NO: 10/673,506	:
FILED: SEPTEMBER 30, 2003	: GROUP ART UNIT: 2825
FOR: SYSTEM AND METHOD FOR USING FIRST-PRINCIPLES SIMULATION TO ANALYZE A PROCESS PERFORMED BY A SEMICONDUCTOR PROCESSING TOOL	:

APPEAL BRIEF UNDER 37 CFR 41.37

COMMISSIONER FOR PATENTS
ALEXANDRIA, VIRGINIA 22313

SIR:

This is an appeal of the Office Action dated February 19, 2008. A Notice of Appeal was filed on May 19, 2008. A final Office Action was mailed July 7, 2008 acknowledging the terminal disclaimer filed and removing the double patenting rejection.

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I. 41.37(C)(1)(I) Real Party of Interest

The real party of interest in this appeal is the assignee Tokyo Electron Limited whose address is Akasaka Biz Tower, 3-1, Akasaka 5-chome, Minato-ku, Tokyo 107-6325, Japan.

II. 41.37(C)(1)(II) Related Appeals and Interferences

There are no related interferences. There are related appeals filed or to be filed in U.S. Serial Nos. 10/673,138; 10/673,467; 10/673,501; 10/673,507; and 10/673,583.

III. 41.37(C)(1)(III) Status of Claims

Claims 1-62 and 66-68 are pending and appealed. Claims 63-65 and 69 have been canceled.

Claim 66 stands rejected under 35 U.S.C. § 101 as being directed to non-statutory subject matter. Claims 1-25, 32-56 and 63-69 stand rejected under 35 U.S.C. § 103(a) as being obvious over Sonderman et al (U.S. Pat. No. 6,802,045) in view of Kee et al (U.S. Pat. No. 5,583,780). Claims 26-31 and 57-62 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Sonderman et al and Kee et al in view of Fatke et al (U.S. Pat. Appl. No. 2005/0016947).

IV. 41.37(c)(1)(iv) Status of Amendments

An amendment was filed for this application on November 21, 2007 which resulted in the non-final Office Action dated February 19, 2008. There are twice-rejected claims in this application. An amendment was filed on May 19, 2008 canceling Claims 63-65 and 69. A terminal disclaimer was also filed on May 19, 2008. A subsequent Office Action was mailed July 7, 2007 indicating the removal of the obviousness-type double patenting rejection.

V. 41.37(c)(1)(v) Summary of Claimed Subject Matter

Claim 1, the first of the independent claims appealed, will be treated as a picture claim representing many of the features in the remaining independent claims. Accordingly, a claim chart for support is provided below showing support from the specification for the claim elements.

In short, Claim 1 defines a method of controlling a process performed by a semiconductor processing tool. The method inputs process data ***relating to an actual process being performed*** by the semiconductor processing tool, and inputs a first principles physical model including a set of computer-encoded differential equations. The first principles physical model describes at least one of a basic physical or chemical attribute of the semiconductor processing tool. The method performs first principles simulation ***for the actual process being performed during performance of the actual process*** using the physical model to provide a first principles simulation result in accordance with the process data relating to the actual process being performed in order to simulate the actual process being performed. The first principles simulation result is ***produced in a time frame shorter in time than the actual process being performed***. The model uses the first principles simulation result obtained during the performance of the actual process to determine a fault in the actual process being performed by the semiconductor processing tool.

Accordingly, Claim 1 makes clear that a first principles simulation result ***for the actual process being performed during performance of the actual process*** is used to determine a fault in the actual process being performed by the semiconductor processing tool.. The following is a claim chart comparison of the claim elements to the disclosure in the specification. Emphasis has been added for convenience in some of the longer passages from the specification.

Claim 1	**Support in U.S. Pat. Appl. No. 10/673,507**
A method of controlling a process performed by a semiconductor processing tool, comprising	Specification, numbered paragraph [0011]: According to an aspect of the invention, a method of controlling a process performed by a semiconductor processing tool includes inputting data relating to a process performed by the semiconductor processing tool, and inputting a first principles physical model relating to the semiconductor processing tool. First principles simulation is then performed using the input data and the physical model to provide a first principles simulation result, and the first principles simulation result is used to control the process performed by the semiconductor processing tool.
inputting process data relating to an actual process being performed by the semiconductor processing tool	Specification, numbered paragraph [0032]: Data input device 104 is a device for collecting data relating to a process performed by the semiconductor processing tool 102 ***and inputting the collected data to the first principles simulation processor 106.*** . . . In one embodiment, the data input device 104 may be implemented as a physical sensor for collecting data about the semiconductor processing tool 102 itself, and/or the environment contained within a chamber of the tool. Such data may include fluid mechanic data such as gas velocities and pressures at various locations within the process chamber, electrical data such as voltage, current, and impedance at various locations within the electrical system of the process chamber, chemical data such as specie concentrations and reaction chemistries at various locations within the process chamber, thermal data such as gas temperature, surface temperature, and surface heat flux at various locations within the process chamber, plasma processing data (when plasma is utilized) such as a plasma density (obtained, for example, from a Langmuir probe), an ion energy (obtained, for example, from an ion energy spectrum analyzer), and mechanical data such as pressure, deflection, stress, and strain at various locations within the process chamber.

i	Specification, numbered paragraph [0039]: FIG. 2 is a flow chart showing a process for using first principles simulation techniques to-facilitate a process performed by a semiconductor processing tool in accordance with an embodiment of the present invention. The process shown in FIG. 2 may be run on the first principles simulation processor 104 of FIG. 1, for example. As seen in FIG. 2, the process begins in step 201 with the inputting of data related to a process performed by the semiconductor processing tool 102. As discussed above, the input data may be data relating to physical attributes of the tool/tool environment and/or data relating to a process performed by the tool on a semiconductor wafer or results of such process. As also described above, ***the input data may be directly input from a physical sensor or metrology tool coupled to the first principles simulation processor 104***, or indirectly input from a manual input device or database.

inputting a first principles physical model including a set of computer-encoded differential equations, the first principles physical model describing at least one of a basic physical or chemical attribute of the semiconductor processing tool;	Specification, numbered paragraph [0035]: First principles physical model 106 is a model of the physical attributes of the tool and tool environment as well ***as the fundamental equations necessary to perform first principles simulation*** and provide a simulation result for facilitating a process performed by the semiconductor processing tool. Thus, the first principles physical model 106 depends to some extent on the type of semiconductor processing tool 102 analyzed as well as the process performed in the tool. For example, the physical model 106 may include a spatially resolved model of the physical geometry of the tool 102, which is different, for example, for a chemical vapor deposition (CVD) chamber and a diffusion furnace. Similarly, the first principles equations necessary to compute flow fields are quite different than those necessary to compute temperature fields. The physical model 106 may be a model as implemented in commercially available software, such as ANSYS, of ANSYS Inc., Southpointe, 275 Technology Drive Canonsburg, Pa. 15317, FLUENT, of Fluent Inc., 10 Cavendish Conn. Centerra Park, Lebanon, N.H. 03766, or CFD-ACE+, of CFD Research Corp., 215 Wynn Dr., Huntsville, Ala. 35805, to compute flow fields, electromagnetic fields, temperature fields, chemistry, surface chemistry (i.e. etch surface chemistry or deposition surface chemistry). However, special purpose or custom models developed from first principles to resolve these and other details within the processing system may also be used.
	Specification, numbered paragraph [0036]: First principles simulations in the present invention include, but are not limited to, simulations of electro-magnetic fields derived from ***Maxwell's equations, continuum simulations, for example, for mass, momentum, and energy transport derived from continuity, the Navier-Stokes equation*** and the First Law of Thermodynamics, as well as atomistic simulations derived from the Boltzmann equation, such as for example Monte Carlo simulations of rarefied gases (see Bird, G. A. 1994. Molecular gas dynamics and the direct simulation of gas flows, Clarendon Press).

performing first principles simulation for the actual process being performed during performance of the actual process using the physical model	Specification, numbered paragraph [0012]: A first principles simulation processor is configured to input a first principles physical model relating to the semiconductor processing tool, and perform first principles simulation using the input data and the physical model to provide a first principles simulation result. The first principles simulation result is used to control the process performed by the semiconductor processing tool. Specification, numbered paragraph [0036]: First principles simulation processor 108 is a processing device that applies data input from the data input device 104 to the first principles physical model 108 to execute a first principles simulation. Specifically, the first principles simulation processor 108 may use the data provided by the data input device 104 to set initial conditions and/or boundary conditions for the first principles physical model 106, which is then executed by the simulation module. Specification, numbered paragraph [0057]: In this embodiment, steady-state simulations are repeatedly run concurrently with the process by using the physical sensor measurements to repeatedly update boundary conditions of the first principles simulation model.
to provide a first principles simulation result in accordance with the process data relating to the actual process being performed in order to simulate the actual process being performed,	Specification, numbered paragraph [0036]: The output of the first principles simulation processor 108 is a simulation result that is used to facilitate a process performed by the semiconductor processing tool 102. For example, the simulation result may be used to facilitate process development, process control and fault detection as well as to provide virtual sensor outputs that facilitate tool processes, as will be further described below.

said first principles simulation result being produced in a time frame shorter in time than the actual process being performed; and	Specification, numbered paragraph [0041]: In step 205, the first principles simulation processor 108 uses the input data of step 201 and the first principles physical model of step 203 to execute a first principles simulation and provide a simulation result. Step 205 may be performed either concurrently with or not concurrently with the process performed by the semiconductor processing tool. For example, simulations that can be performed at short solution times may be run concurrently with a tool process, and results used to control the process. More computationally intensive simulations may be performed not concurrently with the tool process and the simulation result may be stored in a library for later retrieval. In one embodiment, step 205 includes using the input data of step 201 to set initial and/or boundary conditions for the physical model provided in step 205.
	Specification, numbered paragraph [0057]: In this embodiment, steady-state simulations are repeatedly run concurrently with the process by using the physical sensor measurements to repeatedly update boundary conditions of the first principles simulation model.
using the first principles simulation result obtained during the performance of the actual process to determine a fault in the actual process being performed by the semiconductor processing tool.	Specification, numbered paragraph [0012]: The first principles simulation result is used to control the process performed by the semiconductor processing tool.
	Specification, numbered paragraph [0042]: Once the simulation is executed, the simulation result is used to facilitate a process performed by the semiconductor processing tool 102. As used herein, the term "facilitate a process performed by the semiconductor processing tool" includes using the simulation result for example to detect a fault in the process, to control the process, to characterize the process for manufacturing runs, to provide virtual sensor readings relating to the process, or any other use of the simulation result in conjunction with facilitating a process performed by the semiconductor processing tool 102.

	Specification, numbered paragraph [0048]: The present inventors have also discovered that the network architecture of FIG. 3 provides the ability to distribute model results done at one processing tool 102 for one condition set, to other similar or identical tools operating later under the same or similar conditions, so redundant simulations are eliminated. Running simulations only for unique processing conditions at on-tool and standalone modules and re-using results from similar tools that have already known simulated solutions allows for rapid development of lookup libraries containing results that can be used for diagnostics and control over a large range of processing conditions. Further, the reuse of the known solutions as initial conditions for first principles simulation reduces the computational requirements and facilitates the production of simulated solutions in a time frame consistent with on-line control. Similarly, the network architecture of FIG. 3 also provides the ability to propagate changes and refinements made to physical models and model input parameters from one simulation module to others in the network. ***For example, if during process runs and parallel executions of a model it is determined that some input parameters need to be changed, then these changes can be propagated to all other simulation modules and tools via the network.***

Claim 32 defines a system which is similar to the method of Claim 1. Thus, the features of Claim 32 are supported in the specification by numbered paragraphs [0011], [0012], [0032]. [0035], [0036], [0039], [0041], [0042], [0048], and [0057].

Claim 66 defines a computer readable medium containing program instructions for execution on a processor, which is similar to method Claim 1. Thus, the features of Claim 66 are supported in the specification by numbered paragraphs [0011], [0012], [0032]. [0035], [0036], [0039], [0041], [0042], [0048], and [0057].

VI. 41.37(C)(1)(VI) Grounds of Rejection for Review

Whether the rejection of Claim 66 under 35 U.S.C. § 101 should be reversed. Whether the rejection of Claims 1-25, 32-56 and 63-69 under 35 U.S.C. § 103(a) as being obvious over Sonderman et al (U.S. Pat. No. 6,802,045) in view of Kee et al (U.S. Pat. No. 5,583,780) should be reversed. Whether the rejection of Claims 26-31 and 57-62 under 35 U.S.C. § 103(a) as being unpatentable over Sonderman et al and Kee et al in view of Fatke et al (U.S. Pat. Appl. No. 200510016947) should be reversed.

VII. 41.37(C)(1)(VII) ARGUMENTS

A. Regarding the 35 USC 103 Rejection of Claim 1-25, 32-56 and 63-69 over Sonderman et al and Kee et al

Claim 1 defines:

> 1. A method for analyzing a process performed by a semiconductor processing tool, comprising:
> inputting process data relating to an actual process being performed by the semiconductor processing tool;
> inputting a first principles physical model including a set of computer-encoded differential equations, the first principles physical model describing at least one of a basic physical or chemical attribute of the semiconductor processing tool;
> ***performing a first principles simulation for the actual process being performed during performance of the actual process*** using the physical model to provide a first principles simulation result in accordance with the process data relating to the actual process being performed in order to simulate the actual process being performed, ***said first principles simulation result being produced in a time frame shorter in time than the actual process being performed;*** and
> using the first principles simulation result ***obtained during the performance of the actual process*** to determine a fault in the actual process being performed by the semiconductor processing tool. [Emphasis added.]

The February 19, 2008 Office Action makes clear on pages 12-18 that the Examiner and the Appellant disagree as to whether Sonderman et al teach performing a first principles

simulation for an actual process being performed to provide a first principles simulation result in order to simulate the actual process being performed.

Appellant respectfully points out that, at col. 9, lines 46-51, Sonderman et al specifically states:

> The system 100 ***then*** optimizes the simulation (described above) to find more optimal process target (T_i) for each silicon wafer, ***S_i to be processed***. These target values are then used ***t***o generate ***new control inputs, X_{Ti},*** on the line 805 to control ***a subsequent process of a silicon wafer S_i***. [Emphasis added]

The plain reading of this section of Sonderman et al is that the system 100 ***then*** (e.g., at time T1) optimizes the simulation for each silicon wafer, ***S_i to be processed*** (e.g., later at time T2). In other words, the simulation results of Sonderman et al produce a new control input for each silicon wafer ***to be processed***. Thus, Appellant respectfully submits that Sonderman et al teach performing a simulation result for a process to be performed ***before*** performance of the actual process, and do **not** teach the claimed performing first principles simulation ***for the actual process being performed during performance of the actual process***.[1]

Other sections of Sonderman et al support Appellant's position on this matter that the simulation results in Sonderman et al are made prior to controlling a subsequent process. For instance, Figure 4 of Sonderman et al (reproduced below) shows that the simulation results are produced ***ahead of performing a process*** and thus have to be based on historical data.

[1] Appellant also points out that Sonderman et al do not disclose or suggest a first principles simulation.

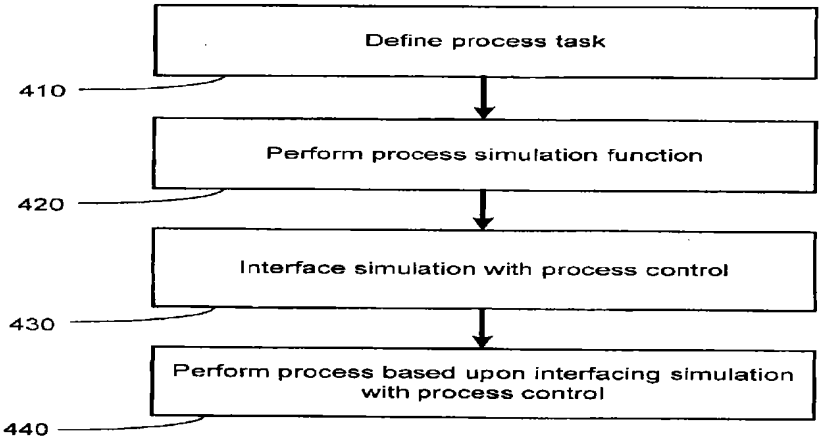


FIGURE 4

With reference to Figure 4, Sonderman et al disclose at col. 6, lines 24-47:

> Turning now to FIG. 4, a flow chart representation of the methods in accordance with the present invention is illustrated. In one embodiment, ***the system 100 defines a process task that is to be performed (block 410).*** The process task may be a photolithography process, an etching process, and the like. ***The system 100 then performs a process simulation function*** (block 420). A more detailed description of the process simulation function described in block 420, is illustrated below. In one embodiment, a simulation data set results from the execution of the process simulation function.
>
> ***Once the system 100 performs the process simulation function, the system 100 performs an interfacing function***, which facilitates interfacing of the simulation data with the process control environment 180 (block 430). The process control environment 180 can utilize the simulation data in order to modify or define manufacturing control parameters that control the actual processing steps performed by the system 100. ***Once the system 100 interfaces the simulation data with the process control environment 180, the system 100 then performs a manufacturing process*** based upon the manufacturing parameters defined by the process control environment 180 (block 440). [Emphasis added]

Hence, the process flow in Sonderman et al is straightforward:

1) define a process to be modeled,

2) model the simulation result,

3) interface simulation result to processor, and then

4) run the process under control based on the pre-existing simulation result.

In the February 19, 2008 Office Action, the examiner disagreed with this interpretation of Sonderman et al. On page 13 of the Office Action, the examiner asserts that

> Fig. 3 shows performing simulation of first principles simulation. Sonderman et al. teach performing first principled simulation that is performed for the actual process being performed during performance of the actual process (col. 7 lines 1-20; col. 8 lines 1-11). Thus, it is not true that Sonderman teach only performing simulation of first principles simulation for the actual process before performance of the actual process. The integrated system described in Fig. 1, 2, 3, 5, 7 and 8) performs first principles simulation for the actual process being performed during performance of the actual process. It can be seen clearly from Fig. 1 and 2, there is interaction between a process control environment 180, a manufacturing processing environment 170, and a simulation environment 210 (col. 4 lines 48-64). Applicants depend on Fig. 4, and argued that Sonderman et al. teach performing first principles simulation for the actual process before performance of the actual process. It is not true because Fig. 1 and 2 described there is interaction between the environments 170, 180 and 210. Clearly Fig. 2 shows that interaction. The environments as shown in Fig. 2 can of course be performed currently and any order. Fig. 3 shows a simulator that controls the process. Fig. 5 & 7 show application of simulation results to manufacturing parameters.

Appellant respectfully points out below that this characterization in Sonderman et al assumes facts not in existence.

1) Regarding the assertion that Figure 3 and col. 7 lines 1-20; col. 8 lines 1-11, of Sonderman et al teach performing first principled simulation that is performed for the actual process being performed during performance of the actual process, col. 7, lines 4-20, of Sonderman et al states:

> Using the validated models, the simulation environment 210 can emulate the operations of an actual process control environment 180 that is integrated with a manufacturing environment 170.
>
> Once the system 100 validates the defined models, the system 100 acquires data to operate the defined models (block 630). In one embodiment, the system 100 acquires data from the computer system 130 in order to operate the defined models. The system 100 then populates the defined models with the data acquired by the system 100 for operation of the models (block 640). In other words, the system 100 sends operation data, control parameter data,

> simulation data, and the like, to the defined models so that the defined models can perform a simulation ***as if an actual manufacturing process were being performed***. The completion of the steps described in FIG. 6 substantially completes the step of preparing process models for simulation, as indicated in block 510 of FIG. 5. [Emphasis added.]

Moreover, col. 8, lines 1-11, of Sonderman et al states:

> The simulation environment 210 modulates variabilities into the defined models (block 710). In other words, the system 100 defines variations into the components of defined models in order to simulate the effects of online manufacturing performance by the models 310, 320, 330. For example, the system 100 invokes a temperature variability of plus or minus 3% of a defined operating temperature into the equipment model 330 ***to simulate the real online manufacturing effects*** of temperature variations in an actual processing environment.

Thus, while it is clear that the simulator in Sonderman et al performs simulations to simulate real online manufacturing effects as if an actual manufacturing process were being performed, Sonderman et al do not disclose in these sections (or other sections) performing first principled simulation that is performed ***for the actual process being performed during performance of the actual process***.

Furthermore, on page 17 of the February 19, 2008 Office Action, the examiner indicates that his interpretation of Sonderman et al's disclosure (noted above) of "so that the defined models can perform a simulation as if an actual manufacturing process were being performed" is that this means performing the first principles simulation for the actual process being performed because the simulation initiates the actual process being performed. While the simulation result needs to be present in Sonderman et al for control of the actual process, this in no way implies that simulation result was obtained ***for the actual process being performed during performance of the actual process***.

2) Regarding the assertion that it can be seen clearly from Fig. 1 and 2 that there is an interaction between a process control environment 180, a manufacturing processing environment 170, and a simulation environment 210 (col. 4 lines 48-64), col. 4 lines 48-64 of Sonderman et al states:

> Referring now to FIGS. 1 and 2 simultaneously, one embodiment of an interaction between a process control environment 180, a manufacturing/processing environment 170, and a simulation environment 210 is illustrated. In one embodiment the process control environment 180 receives input data from the simulation environment 210, which is then used to control the operation of the manufacturing environment 170. The integration of the simulation environment 210 and the process control environment 180 into the manufacturing environment 170 facilitates more accurate control of the processing of semiconductor wafers. The simulation environment 210 allows for testing various manufacturing factors in order to study and evaluate the interaction between the manufacturing factors. This evaluation can be used by the system 100 to prompt the process control environment 180 to invoke more accurate process control.

The interaction described here is one of using simulation results to control a manufacturing environment. Yet, there is no disclosure here of performing first principled simulation that is performed ***for the actual process being performed during performance of the actual process.***

3) Regarding the assertion that the environments as shown in Fig. 2 can of course be performed currently and any order, Appellant submits that this position stated by the examiner is in complete opposition to Figure 4 of Sonderman et al, which as discussed above lays out a straightforward process flow in Sonderman et al of:

1) define a process to be modeled,
2) model the simulation result,
3) interface simulation result to processor, and then
4) run the process under control based on the pre-existing simulation result.

Accordingly, Appellant respectfully submits that Sonderman et al do not disclose and indeed ***teach away*** from the present invention where data input from an actual process being performed is used for producing a first principles simulation result, which is produced for the actual process being performed during performance of the actual process.

Additionally, the February 19, 2008 Office Action makes clear on pages 19-20 that the Examiner and the Appellant disagree as to whether Sonderman et al teach that a first principles simulation result is produced in a time frame shorter in time than the actual process being performed. The Office Action states on pages 19 and 20 that:

> The new added limitation, first principles simulation result being produced in a time frame shorter in time than the actual process being performed is obvious to artisan skill in the technological art. It is well known to artisan skill in the art that speed of processor used to run simulation determines a time frame to produce a simulation result (first principles simulation result as taught by Sonderman). Different speed of processor is available. It is recognized to artisan skill in the art there is an advantage to obtain a simulation result ready (or time frame to produce a simulation result is shorter than the actual process being performed) for the actual process being performed because the simulation result obtained and ready that is used to subsequently or sequentially or concurrently control process being performed would obviously speed up the process. For at least these reasons, the newly added claim limitation is obvious to artisan skill the art.

The fundamental question is whether there are technological difficulties which prohibit a person of ordinary skill in the art to obtain a simulation result in a time frame shorter in time than the actual process being performed.

The February 19, 2008 Office Action in rejecting the present claims supplements the teachings of Sonderman et al with the teachings of Kee et al for their teaching of computer encoded differential equations.

Kee et al deal with the process control of a Rapid Thermal Processing (RTP) tool and do **not** use real time modeling. RTP tools are tools used in semiconductor manufacturing. Kee et al in detail disclose that:

> The modeling apparatus 101 of the instant invention may also be used to perform an inverse analysis to establish the boundary conditions or parameter values required to achieve a certain function of the thermal system. This allows the apparatus to be used to establish the appropriate process parameters and boundary conditions for the thermal system modeled. In accordance with the instant invention, the inverse analysis can be directly carried out by the modeling apparatus ***rather than using the conventional approach, which merely solves the direct problem repeatedly, in a lengthy and costly iterative process***, to determine appropriate input parameters to achieve a desired result. In other words, in accordance with the instant invention, ***once a particular thermal process is modeled for a particular set of control parameters***, the device may then be used to automatically obtain the necessary control parameters to achieve a desired result by providing the modeling apparatus with parameters corresponding to the desired result.
>
> To carry out the inverse analysis, the modeling apparatus 101 includes an inverse parameter input section 104 also connected to input device 103. A user inputs into the modeling apparatus 101 parameters corresponding to desired results, e.g., desired temperature characteristics of the system, which are stored in memory 108. The processing unit 110, under control of modeling program 111, ***uses the previously generated model*** of the thermal system and the parameters held in memory 108 and derives or predicts particular control parameters to meet the constraints entered through the inverse parameter input section 104. This process is more fully described below in connection with the examples provided.[2] [Emphasis added.]

Hence, Kee et al explicitly disclose that a ***previously generated*** model of the thermal system is used to design and control the thermal system. Kee et al exemplify the difficulties of a "conventional approach" which solves spectral radiation transport equations through "a lengthy and costly iterative process." These problems forced Kee et al to use ***pre-generated model results*** for a control process of a RTP process.

Hence, Kee et al. further discredits any suggestion that the examiner may have read from the disclosure of Sonderman et al for real-time simulation and control of an actual process being performed.

[2] Kee et al, col. 4, lines 21-50.

The Supreme Court in *KSR International Co. v. Teleflex Inc. et al. 2007 U.S. LEXIS 4745* reinforced the role of *Graham* factors, teaching away and elements working together in an unexpected and fruitful manner in deciding obviousness. The Court stated that:

> In *United States v. Adams*, 383 U. S. 39, 40 (1966), a companion case to *Graham*, the Court considered the obviousness of a wet battery that varied from prior designs in two ways: It contained water, rather than the acids conventionally employed in storage batteries; and its electrodes were magnesium and cuprous chloride, rather than zinc and silver chloride. The Court recognized that when a patent claims a structure already known in the prior art that is altered by the mere substitution of one element for another known in the field, the combination must do more than yield a predictable result. 383 U. S., at 50-51. It nevertheless rejected the Government's claim that Adams's battery was obvious. The Court relied upon the corollary principle that when the prior art ***teaches away*** from combining certain known elements, discovery of a successful means of combining them is more likely to be nonobvious. *Id.*, at 51-52. When Adams designed his battery, the prior art warned that risks were involved in using the types of electrodes he employed. The fact that the elements worked together in ***an unexpected and fruitful manner*** supported the conclusion that Adams's design was ***not obvious*** to those skilled in the art. [Emphasis added.]

In the present situation, the claimed elements worked together in ***an unexpected and fruitful manner*** as compared to the prior art. For example, since in Sonderman et al there are ***new control inputs*** for each subsequent wafer, one can not compensate for real time excursions from the existing model occurring while the wafer is being processed. In other words, the historically lengthy time for generation of a first principles model simulation would mean that, in Sonderman et al, one is prevented from realizing a real time process control based on a first principles simulation during the actual process being performed. Meanwhile, the claimed processes and systems (by producing a first principles simulation result in a time frame shorter in time than the actual process being performed) permits accurate control of the process even if the system being controlled deviates from its historical behavior.

For all these reasons, Appellant submits that Claims 1, 8, and 75 patentably define over Sonderman et al and Jain et al.

Hence, the 35 U.S.C. § 103(a) rejection of Claims 1-25, 32-56 and 63-69 as being unpatentable over Sonderman et al in view of Jain et al and further in view of Tan et al should be reversed.

B. Regarding the 35 U.S.C. § 103 Rejection of Claims 26-31 and 57-62 over Sonderman et al, Kee et al, and Fatke

The February 19, 2008 Office Action applied Fatke et al to overcome the deficiencies of Sonderman et al regarding the features of Claims 26-31 and 57-62. The Office Action states at page 11:

> Sonderman et al. do not explicitly teach the multivariate analysis comprising a partial least square analysis; defining a set of loading coefficients, computing at least one of mean and standard deviation values. Fatke et al. teach these limitations including defining a correlation matrix in order to improve detection of a feature etch completion process during semiconductor manufacturing to thereby providing accurate and precise completion of an etch process (see abstract, Fig. 4, summary, 0051). Therefore, it would have obvious to one of ordinary skill in the art at the time the invention was made to combine these teachings in to the system as taught by Sonderman et al. in order to provide an accurate and precise completion of a process during semiconductor manufacturing.

Yet, the examiner's position as to why it would have been obvious to combine Fatke et al with Sonderman et al is merely a conclusory statement with no articulated statement as to what features of Fatke et al and Sonderman et al would have to be modified to accept the endpoint detection of Fatke et al. KSR requires an articulated rationale as to why the claimed features are obvious and indicates that conclusory statements are not sufficient.

For the facts of the asserted obviousness rejection here, the endpoint detection of Fatke et al is a plasma etch endpoint detection process. There is no disclosure in Sonderman et al of a plasma etching process. Thus, one does not know how extensively the processing

tools A and B in Sonderman et al would have to be modified under the asserted combination postulated by the examiner. For example, Sonderman et al describe at col. 4, lines 18-30:

> In one embodiment, the manufacturing model 140 defines a process script and input control that implement a particular manufacturing process. The control input signals on the line 123 that are intended for the processing tool A 120 a are received and processed by the first machine interface 115 a . The control input signals on the line 123 that are intended for the processing tool B 120 b are received and processed by the second machine interface 115 b. Examples of the processing tools 120a , 120b used in semiconductor manufacturing processes are steppers, scanners, step-and-scan tools, etch process tools, and the like. In one embodiment, the processing tool A 120a and the processing tool B 120b are photolithography process tools, such as steppers.

Later, at col. 6, lines 1-13, Sonderman et al describe that temperature changes in the equipment model cause changes to the etching process.

These descriptions imply that the etch process tools of Sonderman et al are photolithography etch tools (i.e., wet chemistry etch tools used to remove the exposed photoresist lines). The application of plasma diagnostics to wet chemistry tools (where plasmas are not used) would not lead to end point detection, even if the correlation matrix in Fatke et al were used. Further, converting a wet chemistry etch tool into a plasma etch tool would require considerable rework and redesign of the wet chemistry etch tool and would change its basic principle of operation from wet chemistry dissolution to dry gas etching.

These facts are similar to In re Ratti, 270 F.2d 810, 813, 123 USPQ 349, 352 which reversed an obviousness rejection where the "suggested combination of references would require a substantial reconstruction and redesign of the elements shown in [the primary reference] as well as a change in the basic principle under which the [primary reference] construction was designed to operate.

Thus, given these considerations, the rejections of Claims 26-31 and 57-62 should be reversed.

C. Regarding the 35 U.S.C. § 101 Rejection of Claim 66

Claim 66 defines:

> A computer readable medium containing program instructions for execution on a processor, which when executed by the computer system, cause the processor to perform the steps of:
> inputting process data relating to an actual process being performed by the semiconductor processing tool;
> inputting a first principles physical model including a set of computer-encoded differential equations, the first principles physical model describing at least one of a basic physical or chemical attribute of the semiconductor processing tool;
> performing a first principles simulation for the actual process being performed during performance of the actual process using the physical model to provide a first principles simulation result in accordance with the process data relating to the actual process being performed in order to simulate the actual process being performed, said first principles simulation result being produced in a time frame shorter in time than the actual process being performed; and
> using the first principles simulation result obtained during the performance of the actual process to determine a fault in the actual process being performed by the semiconductor processing tool.

M.P.E.P. 2106.01 indicates that:

> When a computer program is claimed in a process where the computer is executing the computer program's instructions, USPTO personnel should treat the claim as a process claim.

Here, for Claim 66, the claimed computer readable medium contains program instructions for execution on a processor, which when executed by the computer system, cause the processor to perform the recited steps. Thus, this claim should be treated as a process claim. As a process claim, Claim 66 provides a useful, concrete, and tangible result in that it determines a fault in the actual process being performed by the semiconductor processing tool.

Moreover, Appellant points out that the claimed computer readable medium is linked to another statutory class (i.e, a processor). The May 18, 2008 memorandum from John Love

to the Technology Centers (attached in the evidence appendix) indicates that, by being tied to another statutory subject a matter, a process is eligible subject matter. Following the guidance given in the memorandum, Claim 66 identifies "the apparatus that accomplishes the method steps" by reciting the processor. Furthermore, following the guidance given in the memorandum, Claim 66 is **not** a law of nature, natural phenomena, or abstract idea.

Thus, to the extent that the May 18, 2008 memorandum from John Love represents official policy from the U.S. Patent and Trademark Office, Claim 66 should be considered statutory.

Hence, for these reasons, the 35 U.S.C. § 101 rejection of Claim 66 should be reversed.

VIII. 41.37(c)(1)(vii) Claims Appendix Of Claims Involved In Appeal

Attached herewith is a Claims Appendix.

IX. 41.37(C)(1)(IX) Evidence Appendix

One item is in the attached evidence Appendix.

X. 41.37(c)(1)(x) Related Proceedings Appendix

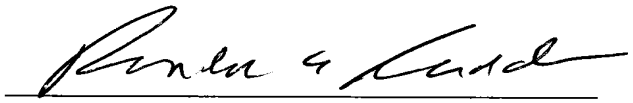
There are no related proceedings.

XI. Conclusion

Appellant request on the basis of the arguments presented above that the outstanding grounds for the rejection be reversed. Appellant submits that the application is in condition for allowance.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, P.C.



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CLAIMS APPENDIX

1. A method for analyzing a process performed by a semiconductor processing tool, comprising:

inputting process data relating to an actual process being performed by the semiconductor processing tool;

inputting a first principles physical model including a set of computer-encoded differential equations, the first principles physical model describing at least one of a basic physical or chemical attribute of the semiconductor processing tool;

performing a first principles simulation for the actual process being performed during performance of the actual process using the physical model to provide a first principles simulation result in accordance with the process data relating to the actual process being performed in order to simulate the actual process being performed, said first principles simulation result being produced in a time frame shorter in time than the actual process being performed; and

using the first principles simulation result obtained during the performance of the actual process to determine a fault in the actual process being performed by the semiconductor processing tool.

Claim 2 The method of Claim 1, wherein said inputting process data comprises directly inputting the data relating to the actual process being performed by the semiconductor processing tool from at least one of a physical sensor and a metrology tool physically mounted on the semiconductor processing tool.

Claim 3 The method of Claim 1, wherein said inputting process data comprises indirectly inputting the data relating to the actual process being performed by the semiconductor processing tool from at least one of a manual input device and a database.

4. The method of Claim 3, wherein said indirectly inputting comprises inputting data recorded from a process previously performed by the semiconductor processing tool.

5. The method of Claim 3, wherein said indirectly inputting comprises inputting data set by a simulation operator

Claim 6 The method of Claim 1, wherein said inputting process data comprises inputting data relating to at least one of the physical characteristics of the semiconductor processing tool and the semiconductor tool environment.

Claim 7 The method of Claim 1, wherein said inputting process data comprises inputting data relating to at least one of a characteristic and a result of a process performed by the semiconductor processing tool.

8. The method of Claim 1, wherein said inputting a first principles physical model comprises inputting a spatially resolved model of the geometry of the semiconductor processing tool.

9. The method of Claim 1, wherein said inputting a first principles physical model comprises inputting fundamental equations as the computer-encoded differential equations necessary to perform first principles simulation for a desired simulation result.

10. The method of Claim 1, wherein said performing first principles simulation comprises performing first principles simulation concurrently with the process performed by the semiconductor processing tool.

11. The method of Claim 1, wherein said performing first principles simulation comprises performing first principles simulation independent of the process performed by the semiconductor processing tool.

12. The method of Claim 1, wherein said performing first principles simulation comprises using the input data to set a boundary condition of the first principles simulation model.

13. The method of Claim 1, wherein said performing first principles simulation comprises using the input data to set an initial condition of the first principles simulation model.

14. The method of Claim 1, wherein said using the first principles simulation result comprises using the first principles simulation result to detect a fault in the process performed by the semiconductor processing tool by comparing said first principles simulation result with said input data.

15. The method of Claim 1, further comprising using a network of interconnected resources to perform at least one of the process steps recited in Claim 1.

16. The method of Claim 15, further comprising using code parallelization among interconnected computational resources to share the computational load of the first principles simulation.

17. The method of Claim 15, further comprising sharing simulation information among interconnected resources to determine the fault in the process performed by the semiconductor processing tool.

18. The method of Claim 17, wherein said sharing simulation information comprises distributing simulation results among the interconnected resources to reduce redundant execution of substantially similar first principles simulations by different resources.

19. The method of Claim 17, wherein said sharing simulation information comprises distributing model changes among the interconnected resources to reduce redundant refinements of first principles simulations by different resources.

20. The method of Claim 15, further comprising using remote resources via a wide area network to determine the fault in the process performed by the semiconductor processing tool.

21. The method of Claim 21, wherein said using remote resources comprises using at least one of remote computational and storage resources via a wide area network to facilitate the semiconductor process performed by the semiconductor processing tool.

22. The method of Claim 1, wherein said performing first principles simulation utilizes at least one of an ANSYS computer code, a FLUENT computer code, a CFRDC-ACE computer code, and a direct simulation Monte Carlo computer code.

23. The method of claim 1, further comprising:

using the first principles simulation result to classify a fault in the process performed by the semiconductor processing tool.

24. The method of Claim 23, wherein said using the first principles simulation result to classify a fault comprises:

calculating a set of perturbation solutions corresponding to the first principles simulation for the input data to generate a profile of data solutions to the first principles simulation.

25. The method of Claim 24, further comprising:

inputting said perturbation solutions to a multivariate analysis;

inputting a difference between said first principles simulation result and said input data to said multivariate analysis; and

utilizing said multivariate analysis to identify a correlation between said input data and said difference.

26. The method of Claim 25, wherein said multivariate analysis comprises:

a partial least squares analysis.

27. The method of Claim 26, further comprising:

defining a set of loading coefficients relating tool perturbation data to process performance data, said loading coefficients describing a difference between simulated results and actual results.

28. The method of Claim 27, wherein said defining comprises:

computing at least one of mean and standard deviation values for the actual results;

generating said loading coefficients based on said at least one of mean and standard deviation values and the simulated results.

29. The method of Claims 25 or 28, further comprising:

attributing said difference between simulated results and input data to one input data using said correlation.

30. The method of Claim 1, wherein said using the first principles simulation result to detect a fault comprises:

detecting a fault in at least one of a material processing system, an etch system, a photoresist spin coating system, a lithography system, a dielectric coating system, a deposition system, a rapid thermal processing system for thermal annealing, and a batch diffusion furnace.

31. The method of Claim 30, wherein said using the first principles simulation result to detect a fault comprises:

detecting a fault in at least one of a chemical vapor deposition system and a physical vapor deposition system.

32. A system comprising:

a semiconductor processing tool configured to perform an actual process;

an input device configured to input process data relating to the actual process being performed by the semiconductor processing tool ; and

a first principles simulation processor configured to:

input a first principles physical model including a set of computer-encoded differential equations, the first principles physical model describing at least one of a basic physical or chemical attribute of the semiconductor processing tool, and

perform a first principles simulation for the actual process being performed during performance of the actual process using the physical model to provide a first principles simulation result in accordance with the process data relating to the actual process being performed in order to simulate the actual process being performed, said first principles simulation result being produced in a time frame shorter in time than the actual process being performed, wherein said first principles simulation result obtained during the performance of the actual process is used to determine a fault in the actual process being performed by the semiconductor processing tool.

33. The system of Claim 32, wherein said input device comprises at least one of a physical sensor and a metrology tool physically mounted on the semiconductor processing tool.

34. The system of Claim 32, wherein said input device comprises at least one of a manual input device and a database.

35. The system of Claim 34, wherein said input device is configured to input data recorded from a process previously performed by the semiconductor processing tool.

36. The system of Claim 34, wherein said input device is configured to input data set by a simulation operator.

37. The system of Claim 32, wherein said input device is configured to input data relating to at least one of the physical characteristics of the semiconductor processing tool and the semiconductor tool environment.

38. The system of Claim 32, wherein said input device is configured to input data relating to at least one of a characteristic and a result of a process performed by the semiconductor processing tool.

39. The system of Claim 32, wherein said processor is configured to input a first principles physical model comprising a spatially resolved model of the geometry of the semiconductor processing tool.

40. The system of Claim 32, wherein said processor is configured to input a first principles physical model comprising fundamental equations as the computer-encoded differential equations necessary to perform first principles simulation for a desired simulation result.

41. The system of Claim 32, wherein said processor is configured to perform said first principles simulation concurrently with the process performed by the semiconductor processing tool.

42. The system of Claim 32, wherein said processor is configured to perform said first principles simulation independent of the process performed by the semiconductor processing tool.

43. The system of Claim 32, wherein said processor is configured to perform said first principles simulation at least by using the input data to set a boundary condition of the first principles simulation model.

44. The system of Claim 32, wherein said processor is configured to perform said first principles simulation at least by using the input data to set an initial condition of the first principles simulation model.

45. The system of Claim 32, wherein said processor is configured to use the first principles simulation result to detect a fault in the process performed by the semiconductor processing tool by comparing said first principles simulation result with said input data.

46. The system of Claim 32, further comprising a network of interconnected resources connected to said processor and configured to assist said processor in performing at least one of the inputting a first principles simulation model and performing a first principles simulation.

47. The system of Claim 46, wherein said network of interconnected resources is configured to use code parallelization with said processor to share the computational load of the first principles simulation.

48. The system of Claim 46, wherein said network of interconnected resources is configured to share simulation information with said processor to determine a fault in said process performed by the semiconductor processing tool.

49. The system of Claim 48, wherein said network of interconnected resources is configured to distribute simulation results to said processor to reduce redundant execution of substantially similar first principles simulations.

50. The system of Claim 48, wherein said network of interconnected resources is configured to distribute model changes to said processor to reduce redundant refinements of first principles simulations.

51. The system of Claim 46, further comprising remote resources connected to said processor via a wide area network and configured to facilitate the semiconductor process performed by the semiconductor processing tool.

52. The system of Claim 51, wherein said remote resources comprise at least one of a computational and a storage resource.

53. The system of Claim 38, wherein said processor is configured to perform first principles simulation by utilizing at least one of an ANSYS computer code, a FLUENT computer code, a CFRDC-ACE computer code, and a direct simulation Monte Carlo computer code.

54. The system of Claim 38, wherein said processor is further configured to use the first principles simulation result to classify a fault in the process performed by the semiconductor processing tool.

55. The system of Claim 54, wherein said processor is configured to classify a fault by calculating a set of perturbation solutions corresponding to the first principles simulation for the input data to generate a profile of data solutions to the first principles simulation.

56. The system of Claim 55, wherein said processor is configured to:

input said perturbation solutions to a multivariate analysis;

input a difference between said first principles simulation result and said input data to said multivariate analysis; and

utilize said multivariate analysis to identify a correlation between said input data and said difference.

57. The system of Claim 56, wherein said processor is configured to perform said multivariate analysis as a partial least squares analysis.

58. The system of Claim 57, wherein said processor is configured to define a set of loading coefficients relating tool perturbation data to process performance data, said loading coefficients describing a difference between simulated results and actual results.

59. The system of Claim 58, wherein said processor is configured to define a set of loading coefficients by:

computing at least one of mean and standard deviation values for the actual results;

generating said loading coefficients based on said at least one of mean and standard deviation values and the simulated results.

60. The system of Claims 56 or 58, wherein said processor is configured to attribute said difference between simulated results and input data to one input data using said correlation.

61. The system of Claim 32, wherein said processor is configured to detect a fault in at least one of a material processing system, an etch system, a photoresist spin coating system,

a lithography system, a dielectric coating system , a deposition system, a rapid thermal processing system for thermal annealing, and a batch diffusion furnace.

62. The system of Claim 61, wherein said processor is configured to detect a fault in at least one of a chemical vapor deposition system and a physical vapor deposition system.

66. A computer readable medium containing program instructions for execution on a processor, which when executed by the computer system, cause the processor to perform the steps of:

inputting process data relating to an actual process being performed by the semiconductor processing tool;

inputting a first principles physical model including a set of computer-encoded differential equations, the first principles physical model describing at least one of a basic physical or chemical attribute of the semiconductor processing tool;

performing a first principles simulation for the actual process being performed during performance of the actual process using the physical model to provide a first principles simulation result in accordance with the process data relating to the actual process being performed in order to simulate the actual process being performed, said first principles simulation result being produced in a time frame shorter in time than the actual process being performed; and

using the first principles simulation result obtained during the performance of the actual process to determine a fault in the actual process being performed by the semiconductor processing tool.

67. The method of Claim 1, wherein said performing a first principles simulation comprises:

providing for the first principles simulation a reuse of known solutions as initial conditions for the first principles simulation.

68. The system of Claim 32, wherein the first principles simulator is configured to provide for the first principles simulation a reuse of known solutions as initial conditions for the first principles simulation.

EVIDENCE APPENDIX

UNITED STATES PATENT AND TRADEMARK OFFICE

COMMISSIONER FOR PATENTS
UNITED STATES PATENT AND TRADEMARK OFFICE
P.O. BOX 1450
ALEXANDRIA, VA 22313-1450

MEMORANDUM

DATE: May 15, 2008
TO: Technology Center Directors
FROM: John J. Love
Deputy Commissioner for Patent Examination Policy

SUBJECT: **Clarification of "Processes" under 35 USC § 101**

Last week, the U.S. Patent & Trademark Office presented its views on subject matter eligibility of process claims to the Court of Appeals for the Federal Circuit in *In re Bilski*, Appeal No. 2007-1130. This memo is to ensure that examiners are examining applications consistent with that view. In particular, this clarification is provided to assist examiners in determining, on a case by case basis, whether a method claim qualifies as a patent eligible process under 35 USC § 101. The following discussion is intended to be used in conjunction with the Interim Guidelines when evaluating whether a claimed invention falls within a statutory category of invention. (See MPEP § 2106.IV.B: *Determine Whether the Claimed Invention Falls Within An Enumerated Statutory Category.*)

As explained in the Interim Guidelines, the first step in determining whether a claim recites patent eligible subject matter is to determine whether the claim falls within one of the four statutory categories of invention recited in 35 USC § 101: process, machine, manufacture and composition of matter. The latter three categories define "things" or "products," while a "process" consists of a series of steps or acts to be performed. For purposes of § 101, a "process" has been given a specialized, limited meaning by the courts.

Based on Supreme Court precedent[1] and recent Federal Circuit decisions, the Office's guidance to examiners is that a § 101 process must (1) be tied to another statutory class (such as a particular apparatus) or (2) transform underlying subject matter (such as an article or materials) to a different state or thing.[2] If neither of these requirements is met by the claim, the method is not a patent eligible process under § 101 and should be rejected as being directed to non-statutory subject matter.

An example of a method claim that would not qualify as a statutory process would be a claim that recited purely mental steps. Thus, to qualify as a § 101 statutory process, the claim should positively recite the other statutory class (the thing or product) to which it is tied, for example by identifying the apparatus that accomplishes the method steps, or positively recite the subject

[1] *Diamond v. Diehr*, 450 U.S. 175, 184 (1981); *Parker v. Flook*, 437 U.S. 584, 588 n.9 (1978); *Gottschalk v. Benson*, 409 U.S. 63, 70 (1972); *Cochrane v. Deener*, 94 U.S. 780, 787-88 (1876).
[2] The Supreme Court recognized that this test is not necessarily fixed or permanent and may evolve with technological advances. *Gottschalk v. Benson*, 409 U.S. 63, 71 (1972).

matter that is being transformed, for example by identifying the material that is being changed to a different state.

If the claimed method is determined to be a statutory subject matter eligible process, the inquiry proceeds to determine whether the claimed invention falls within a judicial exception (law of nature, natural phenomena, or abstract idea), as explained in detail in the Interim Guidelines. Determining whether the claimed invention is directed to a statutory category of invention is a separate inquiry from whether the claimed invention falls within a judicial exception and whether the invention is limited to a specific practical application of a judicial exception. A complete examination of the pending claims should be made so that all potential rejections and objections are raised normally in the first Office action on the merits. Examiners should use the criteria in this memo for the first step in the analysis for statutory subject matter eligibility of process claims under § 101 and refer to the Interim Guidelines (MPEP 2106.IV.C.) for the additional analysis with respect to determining whether a claim is directed to a judicial exception and whether the invention has a practical application.

The state of the law with respect to statutory subject matter eligibility under § 101 is evolving and is presently an issue in several cases under appeal at the Federal Circuit. As the pending cases on appeal are decided, the Interim Guidelines will be revised to reflect any additional guidance the Office receives from the courts. Examiners are encouraged to seek assistance from their managers and pertinent training materials.

RELATED PROCEEDINGS APPENDIX

None